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STOMACH MORPHOLOGY AND FIRST RECORD OF THE FRESHWATER SHRIMP *Macrobrachium potiuna* PREYING ON JUVENILE TREEFROG IN THE ATLANTIC FOREST

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Abstract: We present the first report of *Macrobrachium potiuna* (Arthropoda: Decapoda) preying on an juvenile anuran, alongside with a description of the stomach morphology of the shrimp individual. The freshwater shrimp was observed feeding on a juvenile hylid in the Atlantic Forest. We interpret the shrimp's behavior as opportunistic predation instead of necrophagy due to the small size of the treefrog and the absence of decomposition. We also briefly discuss some ecological theories that might be used to explain this trophic relationship. Shrimp dissection revealed no gastric mill or other maceration structures, but the stomach contents included dendrites and tissues of the prey, as well as two insect eggs from the order Diptera. Our findings contribute to the limited knowledge on the diet, anatomy, and trophic relationships of freshwater shrimps.

Keywords: Amphibia; Southeastern Brazil; Crustacea; Predation

Freshwater shrimps are crucial for maintaining the trophic structure of lotic environments as they have an omnivorous diet that promotes nutrient cycling and energy flow in headwater streams (Carvalho *et al.* 2011, Cruz *et al.* 2021). They feed on organic plant debris in suspension or in the substratum (Carvalho *et al.* 2011, Jimoh *et al.* 2011, Lima *et al.* 2014), as well as on insects, oligochaetes, microcrustaceans, mollusks, and small fish (Mirzajani *et al.* 2020). For example, the predation of dipteran larvae by the shrimp *Macrobrachium inpa* Kensley & Walker, 1982 can regulate the population dynamics of these insects (Landeiro *et al.* 2008). This feeding pattern is also observed in the predation of ephemeropterans by *Macrobrachium americanum* Bate, 1868 (Moulton *et al.* 2004).

Although less frequent, there are reports of anuran eggs and tadpoles as food items for some freshwater shrimp and crab species (Warkentin 1999, Warren *et al.* 2021). Other arthropods can prey on juvenile forms of anurans, such as spiders (Nyffeler & Altig 2020), harvestmen (Menegucci *et al.* 2020), and water bugs (González-Maya *et al.* 2019). The predation risk for tropical anurans is higher during their activity peak, which for

most tropical species occurs in the wet and warm season. During this period (between October and March in southeastern Brazil), higher anuran activity can increase their exposure to predators (Duellman & Trueb 1994). However, the frequency of post-metamorphic anuran predation rates by invertebrates is highly dependent on the presence of specialized tactics by the predators (Toledo *et al.* 2007). For example, smaller invertebrates with predatory tactics such as venom or social foraging behavior are more likely to consume prey of equal or larger size, while non-venomous or solitary invertebrates tend to consume smaller prey (Toledo *et al.* 2007).

On December 10, 2021 (summer), during a fieldwork carried out at the Reserva Particular do Patrimônio Natural Trápaga, São Miguel Arcanjo municipality, in the state of São Paulo, southeastern Brazil (24º3'20.938"S; 47º58'48.414"W, WGS84; 784 m a.s.l.), we observed a male individual of *Macrobrachium potiuna* Müller 1880 (carapace length of 45 mm) feeding on a small-sized juvenile treefrog (snout-vent length ca. 25 mm, ~ 55% of the shrimp size) (Figure 1). These anurans are primarily arboreal and usually inhabit stream beds, bromeliads, or rocky cavities in the Atlantic Forest (Frost 2011). Both shrimp and treefrog individuals were collected under ICMBio and SISBIO permits (#73355, #73380, #79423-2, and #79423-3) and deposited at the Didactic Entomological Collection of the Zoology Department of the Universidade Federal de Juiz de Fora.

Macrobrachium potiuna "*stricto sensu*" is distributed across upland forest areas in the states of Santa Catarina, Paraná, and São Paulo, occurring in sandy streams with diverse marginal vegetation (Müller & Carpes 1991, Mattos & Oshiro 2009). Although studies have been conducted on its reproductive biology, population dynamics, and taxonomy (Mattos & Oshiro 2009; Pileggi & Mantelatto 2013), no study to date reported on its diet or foraging strategies. However, information on the diet composition allows to identify feeding habits, determine the trophic position, and distinguish species (Lima *et al.* 2014, Mirzajani *et al.* 2020). Furthermore, the description of a species' digestive system (dimensions and shapes) can provide insights into its habits and feeding preferences (Karasov *et al.* 2011). To enhance our knowledge regarding the trophic relationships of *M. potiuna* in natural systems and to provide new natural history information on the species, we described the morphology of the digestive tract and the food items found within it, following the methods proposed by Lima *et al.* (2016).

The *M. potiuna* individual had a 3 mm long stomach (Figure 2), and its cardiac stomach was located posterior to the head and lacked a gastric mill. The cardiac sac was concave and had rough, striated muscles. During the dissection process, the stomach and pyloric filter were accidentally dismembered. Inside the stomach, we identified tissues from a hylid species, along with detritus and two Diptera eggs.

We presume that the observed predation event was opportunistic because there are no similar cases reported for other species of *Macrobrachium*, despite the predatory habit of other freshwater shrimp species (Warren *et al.* 2021). We discard the possibility of necrophagy because usually the eye socket is the first structure to decompose, and the prey eye socket did not show any signals of decomposition. In addition, the shrimp individual was twice as large as the anuran, indicating the possibility of predation.

We indicate two potential hypotheses to explain this behavioral episode. The first is related to changes in food availability for *M. potiuna*. December 2021 was characterized by intense rainfall concentrated in a few hours of the day (Agritempo 2022). Such intense rainfall increases the water flow and the current in streams that, despite stirring up the suspended benthic substrate, can also reduce the availability of the preferred food for *Macrobrachium* (Esteves 2011), such as eggs and larval stages of insects (Minshall & Minshall 1977, Bunn & Arthington 2002). The second hypothesis is related to the increasing foraging activity that occurs during the reproductive peak of shrimps *Macrobrachium* spp. in December (Sampaio *et al.* 2007). Obtaining body biomass and energy are essential for the production and maturation of viable sperm in males, in addition to success in their competition for females (Pérez-Rodríguez *et al.* 2019).

According to Carvalho *et al.* (2013), the populations of *M. potiuna* split into two different lineages, "*stricto sensu*", distributed across the Brazilian Plateau, and "*Affinis*-Clade", distributed

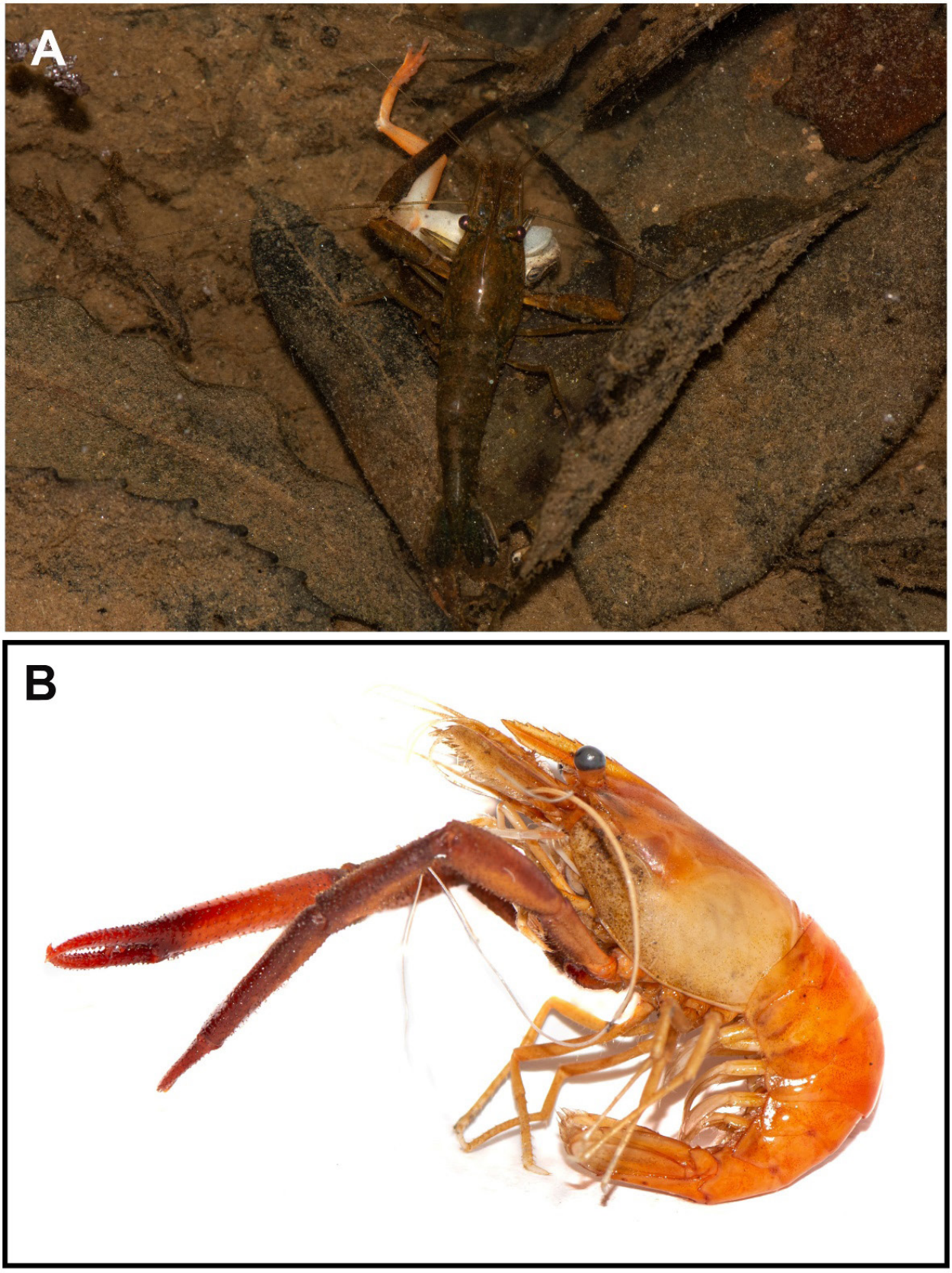

Figure 1. *Macrobrachium potiuna* feeding on juvenile treefrog at the Reserva Particular do Patrimônio Natural Trápaga, São Miguel Arcanjo, São Paulo, Brazil (A); collected individual of *M. potiuna* (B). Photo credits: Bruno Ferreto Fiorillo.

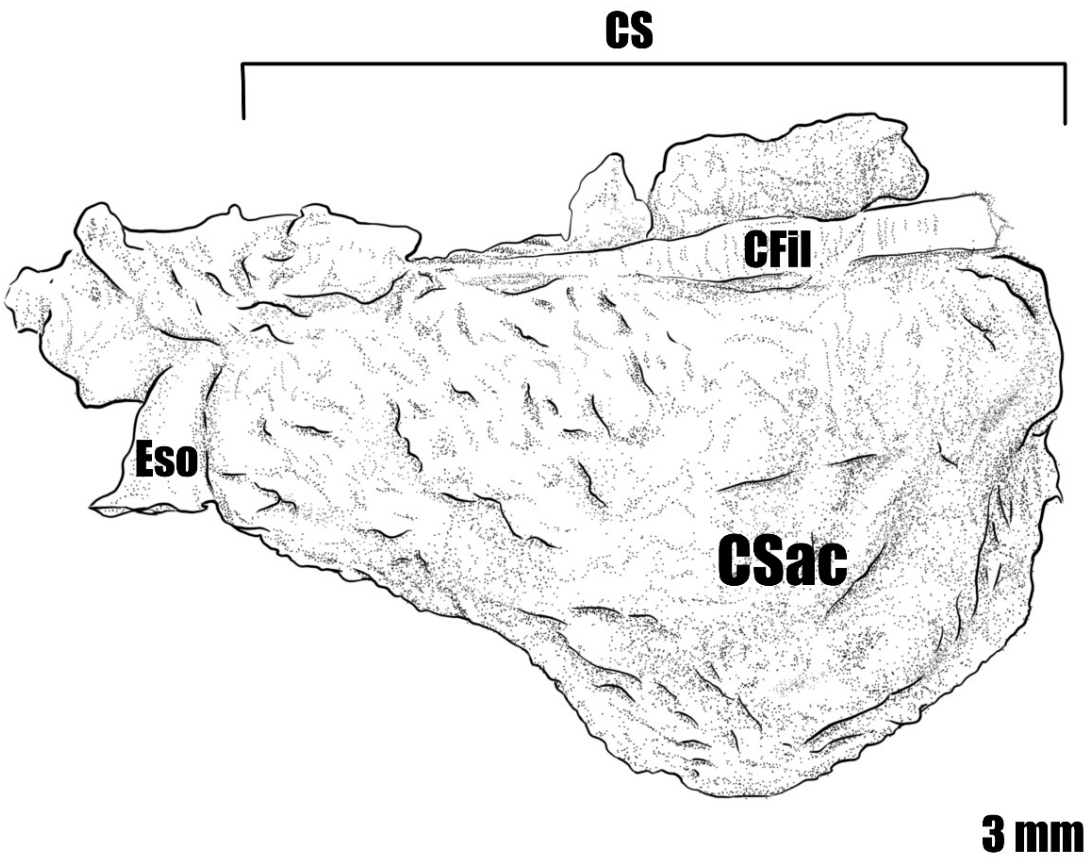

Figure 2. Esophagus and stomach morphology of *Macrobrachium potiuna*. CS = Cardiac stomach; CFil = Cardiac filament; CSac = Cardiac sac; Eso = Esophagus. Illustration credits: Dra. Samyra Furtado.

in floodplain areas of the states of Minas Gerais and Bahia. In this context, research that investigates morphological differences in the digestive tract and diet among different clades is desirable, since environmental conditions (apart from biogeographic factors) can influence the availability of food resources (Tundisi & Tundisi 2008) that can potentially lead to morphological differences amongst clades (Goodheart *et al*. 2017).

As far as we know, this is the first report of juvenile anuran predation by *Macrobrachium* and the first available diet record of *M. potiuna*. Moreover, we present the first description of its digestive tract morphology. We highlight that amphibians are important in the composition of food webs (Blaustein *et al*. 2011, Davenport & Chalcraft 2012, Zipkin *et al*. 2020), and emphasize the urgent need for quantitative research on predator-prey relationships between crustaceans and amphibians that can deepen the knowledge of the basic ecology and trophic levels of these groups.

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